
ELEC 681 – Fundamentals of Machine Learning

Spring 2016 Syllabus

This course introduces the formal concepts and the basic intuition of machine learning. ELEC 681 provides a foundation for specialized research and advanced study in topics shared by machine learning, statistical inference, and signal processing. Prerequisites: Linear Algebra, Probability Theory, Convex Optimization

Course Outline

Introduction

- Overview
- Supervised Learning
 - Classification
 - Regression
- Unsupervised Learning
- Reinforcement Learning
- Other Scenarios

Supervised Learning

- Background
- Vapnik-Chervonenkis (VC) Dimension
- Probably Approximately Correct (PAC) Learning
- Model Selection

Classification

- Decision Trees
- Bayesian Classifier
- Nearest Neighbor
- Discriminant Functions
- Support Vector Machines (SVMs)
- Kernel Machine
- Artificial Neural Networks
 - Perceptrons
 - Multilayer Perceptrons
 - Hybrid Algorithms

Bayesian Decision Theory

- Discriminant Functions
- Utility Theory
- Association Rules

Parametric Methods

- Maximum Likelihood Estimation
- Bias/Variance
- Parametric Classification
- Parametric Regression
 - Linear Regression
 - Logistic Regression

Multivariate Methods

- Multivariate Data
- Multivariate Classification
- Multivariate Regression

Unsupervised Learning

- Background
- Density Estimation
- Clustering
 - k-Means
 - Latent Variable Models
 - Expectation Maximization
 - Hierarchical
- Dimensionality Reduction

Dimensionality Reduction

- Principal Components Analysis (PCA)
- Kernel Principal Component Analysis (KPCA)
- KPCA and manifold learning
 - Isomap
 - Laplacian eigenmaps
 - Locally linear embedding (LLE)
- Johnson-Lindenstrauss lemma
- Factor Analysis

Graphical Models/Bayesian Networks

- Naïve Bayes
- Hidden Markov Model
- Linear Regression
- d-Separation
- Belief Propagation
- Undirected Graphs

Local Models

- Radial Basis Functions
- Rule-Based Knowledge
- Learning Vector Quantization
- Normalized Basis Functions
- Competitive Basis Functions

Hidden Markov Models

- Evaluation Problem
- State Sequence
- Model Parameters

Ensemble Learning

- Bagging
- Boosting

Reinforcement Learning

- Background, e.g., Bellman Equations
- Markov Decision Process (MDP)
- Model-Based Learning/Planning algorithms
 - Value iteration
 - Policy iteration
 - Linear programming
- Temporal Difference (TD) Learning
- Learning algorithms
 - TD(0)
 - Q-learning
 - SARSA
 - TD(λ)

Course Reading

Required Textbook:

Ethem Alpaydin, *Introduction to Machine Learning*, MIT Press, 2014.

Optional Textbooks:

Christopher Bishop, *Pattern Recognition and Machine Learning*, Springer, 2006.

Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalker, *Foundations of Machine Learning*, MIT Press, 2012.

Further Reading:

OWL-Space postings for each class.

Course Grading

25% - Final Exam (take-home)

25% - Homework

40% - Group Project

10% - Participation

ALL assignments must be completed, or you will receive an incomplete for the course.

Homework Policy

Homework will be posted each week on OWL-Space by class on Friday. It is due by class the following week.

Study Groups

Students may discuss and work on the homework assignment together; however, students must always submit their own work according to the **Honor Code**.

Group Project

A significant portion of the grade will be based on a *Group Project*. Students are encouraged to form groups of 3 or 4, perhaps from their *Study Groups*.

Other Information

Instructor:

Stephan Schwanauer, Duncan Hall 2031, 713-348-2248, sms7@rice.edu, Office Hours: TBD

Assistant:

Etienne Ackermann, Etienne.Ackermann@rice.edu

Class:

02:00PM - 04:59PM on Fridays at AEL A121